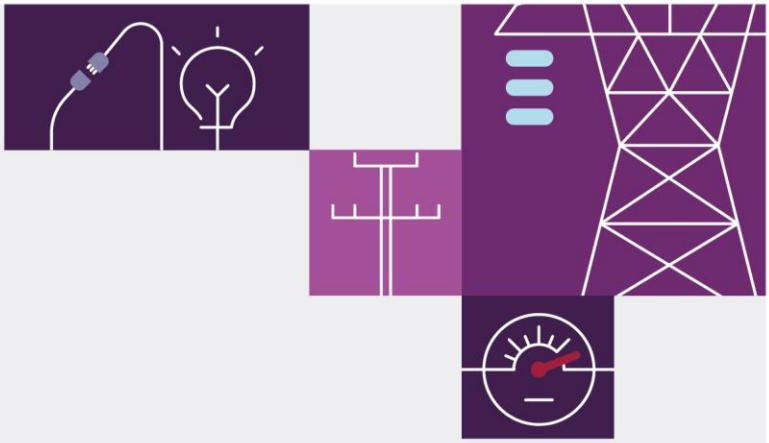
# Appendix 5. Network investments

December 2021

Appendix to Draft 2022 ISP for the National Electricity Market



# Important notice

## Purpose

This is Appendix 5 to the Draft 2022 *Integrated System Plan* (ISP), available at https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp.

AEMO publishes this Draft 2022 ISP under the National Electricity Rules. This publication has been prepared by AEMO using information available at 15 October 2021. Information made available after this date may have been included in this publication where practical.

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### Version control

| Version | Release date | Changes |
|---|---|---|
| 1.0 | 10/12/2021 | Initial release. |

# Draft ISP Appendices

# Contents



## Tables



## Figures

## A5.1 Introduction

This Appendix 5 provides detail on the transmission network investment which form part of the draft optimal development path (ODP) for the Draft 2022 Integrated System Plan (ISP). These network investments ensure there is sufficient network capacity so that resources can be shared between regions, Renewable Energy Zones (REZs) are able to transfer their energy to the load centres, and the power system is secure and reliable. It sets out:

- **A5.2 Transmission development overview** – this section contains an overview of the network investments in the optimal development path.
- **A5.3 Committed and anticipated ISP projects** – this section describes the committed network projects and anticipated projected including timing, cost and technical details. These projects already have regulatory approval and are highly likely to proceed.
- **A5.4 Actionable ISP projects –** this section describes the optimal timing, costs and technical detail for actionable ISP projects. These projects are underway or should commence the relevant regulatory process immediately after publication of the 2022 ISP.
- **A5.5 Future ISP projects** – this section describes the optimal timing, costs and technical detail for the future ISP Projects. These projects will deliver net market benefits to consumers but are not needed until later in the horizon.

## A5.2 Transmission development overview

The development path identified by AEMO as the ODP in the Draft ISP includes a set of network investments which are coordinated and integrated with the projected development of new generation, storage, and DER, to deliver the best outcomes for consumers across a range of scenarios and sensitivities. These network investments are categorised as:

- **Flow path augmentations** – Upgrades to the portion of the transmission network used to transport significant amounts of electricity across the backbone of the interconnected network to load centres.
- **REZ expansions** – Expansion of the network required to connect renewable generation in areas where clusters of large-scale renewable energy can be developed using economies of scale.

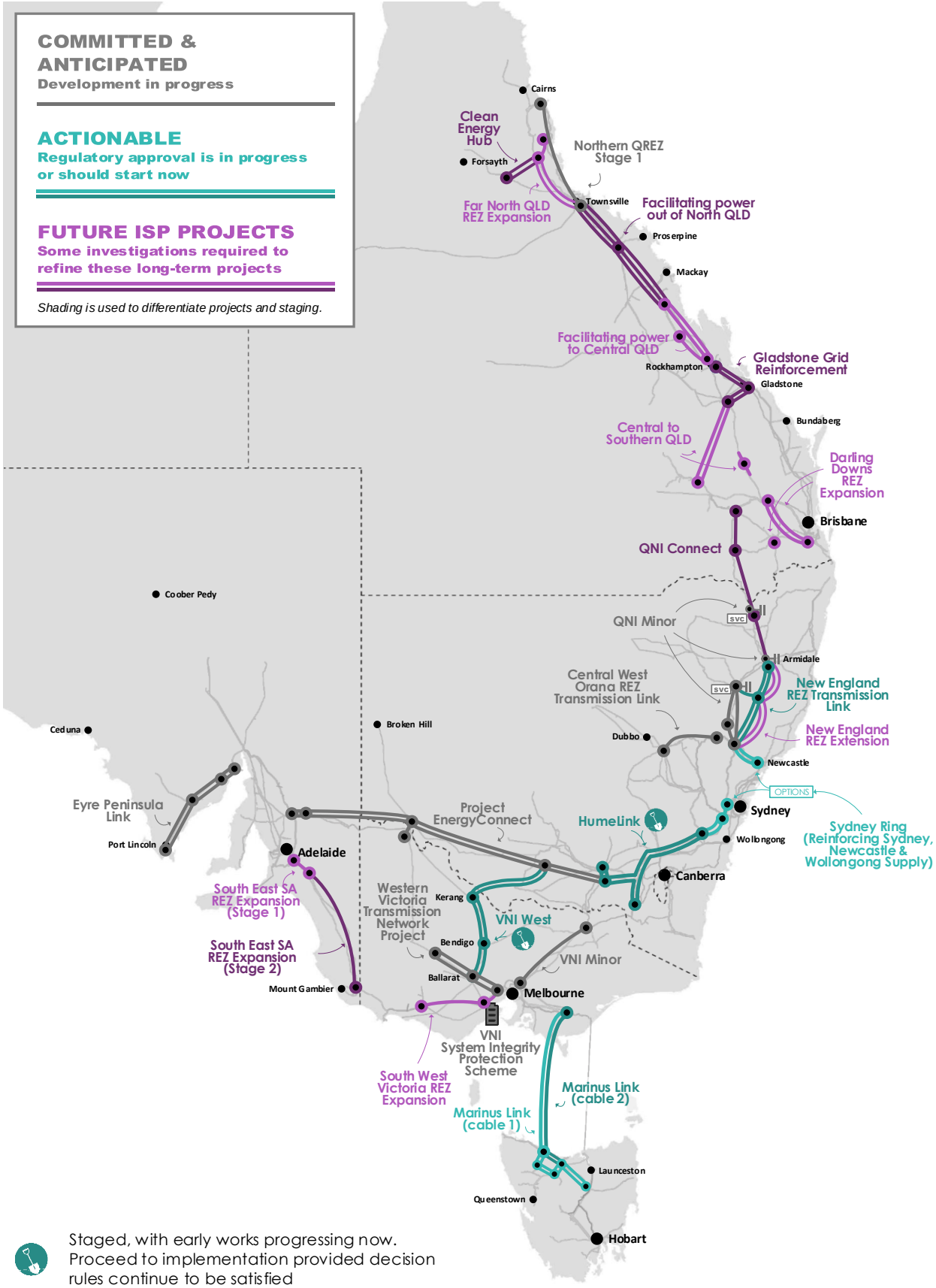
Depending on the timing and urgency of a transmission project, it becomes classified as:

- **Committed and anticipated ISP projects** meet all five commitment criteria (relating to site acquisition, components ordered, planning approvals, finance completed, and construction timing is set[1]). Anticipated projects are in the process of meeting three out of five commitment criteria.
- **Actionable ISP projects** deliver positive net market benefits to consumers if built as soon as possible, and so are already underway or should commence the relevant regulatory process immediately after publication of the 2022 ISP.
- **Future ISP projects** will deliver net market benefits to consumers but are not needed until later in the horizon.

The network projects in the draft ODP are shown in Figure 1.

[1] AEMO ISP Methodology August 2021 available at https://aemo.com.au/-/media/files/major-publications/isp/2021/2021-isp-methodology.pdf?la=en

**Figure 1 Summary of the Draft ISP optimal development path**




† Additional projects to expand REZs and upgrade flow paths after 2040 are highly uncertain, vary significantly between scenarios, and are not shown in this map. See Section A5.5.12 for more information.

## Transmission costs

AEMO has undertaken significant steps towards improving the accuracy and transparency of transmission costs used for the 2022 ISP, following feedback from stakeholders on the 2020 ISP. The resulting *2021 Transmission Cost Report*[2] and associated public database are world-leading initiatives in transparency and information provision in relation to regulated transmission builds.

The Transmission Cost Report was published in July 2021, setting out:

- the methodology used for transmission cost estimation and review of TNSP cost estimates,
- a transparent Transmission Cost Database,
- a breakdown of the design, capacity and cost estimates for each augmentation option, and
- generator connection and system strength remediation costs.

A challenge remaining is that there is no standardisation on the specific class or accuracy level for project cost estimates between the ISP, RIT-T and Contingent Project Application (CPA) processes. It is hoped that AEMC will include this consideration in its 'Transmission Planning and Investment Review'[3].

Since the Transmission Cost Report was issued in July 2021, further updates have been made to the Transmission Cost Database to improve the representation of the property and biodiversity costs. While there have been significant changes to these individual cost components, there have been relatively minor changes to the total costs of ISP projects estimated by AEMO, with the majority of project costs within 5% of the original estimate. As a result, no changes have been made to cost assumptions in the Draft 2022 ISP (Draft ISP) modelling. The latest version of the Transmission Cost Database and an updated user manual is available on AEMO's website[4].

[2] At https://aemo.com.au/en/consultations/current-and-closed-consultations/transmission-costs-for-the-2022-integrated-system-plan.

[3] At https://www.aemc.gov.au/market-reviews-advice/transmission-planning-and-investment-review.

[4] AEMO. *Current Inputs, Assumptions and Scenarios*, at https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp/current-inputs-assumptions-and-scenarios.

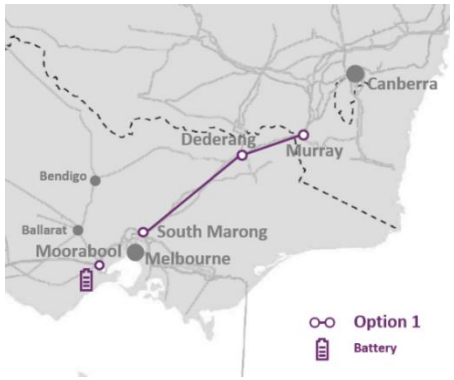
## A5.3 Committed and anticipated ISP Projects

AEMO includes all committed and anticipated transmission projects in all scenarios. The projects are modelled with a fixed time across each scenario. Currently, AEMO has modelled four committed transmission projects and four anticipated projects. The details of these projects are discussed below.

### A5.3.1 Victoria to New South Wales System Integrity Protection Scheme (VNI SIPS)

**Summary**

At the request of Victorian Government, AEMO has procured a system integrity protection scheme (SIPS) that will increase New South Wales to Victoria transfer capabilities (import into Victoria) of the VNI by up to 250 MW from November to March each year. The Victorian Big Battery Ltd is contracted to provide fast response battery services connected at Moorabool as part of the VNI SIPS. The SIPS service will remove overload on VNI by rapidly responding to inject power from batteries at Moorabool after a contingency event on VNI. This allows VNI to run to its 5-minute thermal rating, rather than the 15-minute ratings that would typically apply. This is a committed project and expected to be in service by end of 2021†.




**Existing network capability**

The existing network transfer capability from New South Wales to Victoria depends on thermal capacity of VNI and voltage collapse limit. This transfer capability is highly variable and depending on dispatch of Murray and North-East hydro generation and renewable generation in Central North Victoria.

**Augmentation sequences**

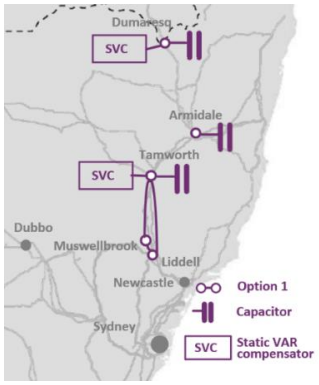
| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | *Progressive Change* | *Step Change* | *Slow Change* | *Hydrogen Superpower* |
|---|---|---|---|---|---|---|---|
| Option 1:<br>A System Integrity Protection Scheme (SIPS) that allows to operate South Morang–Dederang–Murray 330 kV lines to their 5-minute thermal rating following a credible contingency. | Committed | NSW to VIC direction<br>250 MW<br>(from 1 November to 31 March in each year) | Committed project | January Summer 2021- 22‡ | | | |

† AEMO. 2021 *Victorian Annual Planning Report*. https://www.aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/vapr/2021/2021-victorian-annual-planning-report.pdf?la=en.
‡ The VNI SIPS project is expected to be in service at or just after release of this Draft ISP.

## A5.3.2 Queensland to New South Wales Interconnector Minor (QNI Minor)

**Summary**

A minor upgrade to QNI was recommended as urgently needed in the 2018 ISP. Since that time, Powerlink and Transgrid have completed a RIT-T to confirm the optimal solution. The outcome from this RIT-T, which was published in the project assessment conclusions report on 20 December 2019*, confirms the solution recommended in the 2018 ISP. This project gained regulatory approval from the AER in March 2020†. This is a committed project and currently on track for completion by mid-2022‡.




**Existing network capability**

QNI transfer capability is influenced by output of Sapphire generation and generation at 132 kV or lower voltages and load in Northern New South Wales. New South Wales to Queensland transfer capability via QNI in limited by voltage or transient stability limits or thermal capacity of 330 kV lines between Liddell and Muswellbrook/Tamworth. With Sapphire generation at full output of 270 MW, New South Wales to Queensland (northerly direction) transfer capability via QNI ranges from 455 MW to 565 MW. With no Sapphire generation, New South Wales to Queensland transfer capability via QNI ranges from 190 MW to 300 MW.

Queensland to New South Wales (southerly direction) transfer capability via QNI in limited by voltage or stability limits or thermal capacity of 330 kV lines within northern New South Wales. With Sapphire generation at full output of 270 MW, Queensland to New South Wales transfer capability via QNI ranges from 815 MW to 915 MW. With no Sapphire generation, Queensland to New South Wales transfer capability via QNI ranges from 1,095 to 1,145 MW.

**Augmentation sequences**

| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | *Progressive Change* | *Step Change* | *Slow Change* | *Hydrogen Superpower* |
|---|---|---|---|---|---|---|---|
| Option 1:<br>• Uprating of Liddell-Muswellbrook, Muswellbrook-Tamworth and Liddell-Tamworth 330 kV lines.<br>• Install -100/+350 MVAr static var compensators at each of the Dumaresq and Tamworth substations.<br>• Install 240 MVAr, 330 kV shunt capacitor banks at each of the Dumaresq and Tamworth substations.<br>• Install 220 MVAr, 330 kV shunt capacitor banks at Armidale substation. | Committed | Northerly direction 150 MW<br>Southerly direction 145-245 MW | Committed project | July 2022 | | | |

* Transgrid and Powerlink. *Expanding NSW-QLD transmission transfer capacity PACR*, at https://www.transgrid.com.au/media/xlbltudu/expanding-nsw-qld-transmission-transfer-capacity-project-assessment-conclusions-report-pacr-full-report.pdf.
† AER. *Expanding NSW-QLD Transmission Transfer Capacity RIT-T*, at https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/contingent-projects/transgrid-expanding-nsw-qld-transmission-transfer-capacity-regulatory-investment-test-transmission-rit-t.
‡ As per the 2021 IASR, commissioning and internetwork testing are planned to commence in January 2022 and conclude in June 2022. AEMO assumes full capacity will be available from 1 July 2022.

## A5.3.3 Eyre Peninsula Link

**Summary**

The Eyre Peninsula Link project involves the augmentation of the transmission network on the Eyre Peninsula in South Australia. This project will replace an ageing 132 kV single-circuit from Cultana to Yadnarie to Port Lincoln with a high thermal capacity new double-circuit line that simultaneously ensures reliable electricity supply to the Eyre Peninsula. ElectraNet completed the RIT-T and gained regulatory approval from the AER in September 2020†. This is a committed project and currently on track for completion by end of 2022.


**Existing network capability**

The Eyre Peninsula is currently served by a radial 132 kV transmission line which runs from Cultana to Yadnarie to Port Lincoln.

**Augmentation sequences**

| Description | Status | Network capacity (MW) | Expected cost ($ million) | *Progressive Change* | *Step Change* | *Slow Change* | *Hydrogen Superpower* |
|---|---|---|---|---|---|---|---|
| Option 1:<br>• A new 132 kV double-circuit line from Cultana to Yadnarie (constructed with the option to be energised at 275 kV if required in the future).<br>• A new 132 kV double-circuit line from Yadnarie to Port Lincoln. | Committed | Cultana-Yadnarie 300 MVA<br>Yadnarie-Port Lincoln 240 MVA | Committed project | December 2022 | | | |

† AER. ElectraNet – Eyre Peninsula Reinforcement contingent project, at https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/contingent-projects/electranet-%E2%80%93-eyre-peninsula-reinforcement-contingent-project.

## A5.3.4 Victoria to New South Wales Interconnector Minor (VNI Minor)

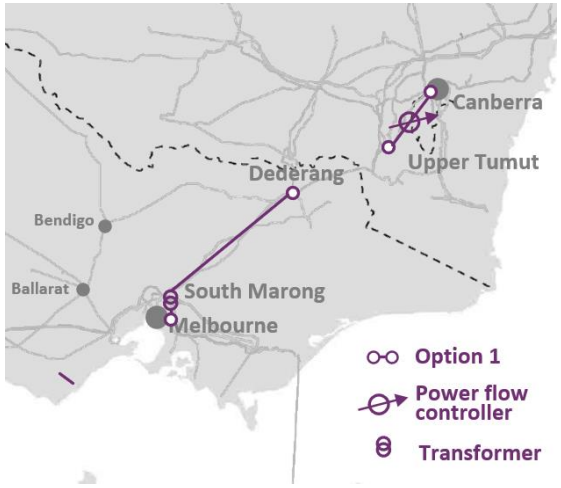
**Summary**

A minor upgrade to the VNI was recommended for immediate action in the 2018 ISP. Since that time, AEMO and Transgrid completed a RIT-T to confirm the optimal solution. The outcome from this RIT-T, which was published in the project assessment conclusions report in February 2020†, largely confirms the solution recommended in the 2018 ISP. This project gained regulatory approval from the AER in April 2021‡. This project is a committed project and on track for completion in 2022–23.

The VNI Minor project is to increase the Victoria to New South Wales transfer capability by up to 170 MW by increasing the thermal capacity of limiting elements.

**Existing network capability**

At times of high demand in New South Wales, Victoria to New South Wales transfer capability is limited to 700 MW by thermal capacity of South Morang 500/330 kV transformer, South Morang–Dederang 330 kV lines and Upper Tumut–Canberra 330 kV lines.




**Augmentation sequences**

| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | *Progressive Change* | *Step Change* | *Slow Change* | *Hydrogen Superpower* |
|---|---|---|---|---|---|---|---|
| Option 1:<br>• Uprate South Morang–Dederang 330 kV line.<br>• An additional new 500/330 kV transformer at South Morang.<br>• Power flow controllers on Upper Tumut-Yass and Upper Tumut-Canberra 330 kV lines. | Committed | VIC to NSW direction up to 170 MW | Committed project | December 2022 | | | |

† AEMO and TransGrid. *Victoria to New South Wales Interconnector Upgrade PACR*, at https://www.transgrid.com.au/media/24nhbaux/victoria-to-new-south-wales-interconnector-upgrade-rit-t-pacr.pdf.
‡ AER. *TransGrid – Expanding Victoria-New South Wales Transmission Transfer Capacity (VNI) Contingent Project Application*, at https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/contingent-projects/transgrid-%E2%80%93-expanding-victoria-new-south-wales-transmission-transfer-capacity-vni-contingent-project-application.

## A5.3.5 Northern Queensland REZ (QREZ) Stage 1

**Summary**

In August 2020, the Queensland Government committed $145 million to establish three REZs in Queensland. It was further announced in May 2021 that the northern zone (which includes the Far North Queensland region) would direct $40 million of this committed funding in transmission infrastructure to establish the Northern QREZ†.

The scope of the network upgrades is to establish a third 275 kV connection into the Woree Substation, with all associated works to commence Quarter 4 2021 and to be completed by November 2023. Works associated falls outside the bounds of the RIT-T due to the external nature of the funding provided which will facilitate non-regulated opportunities and developments in Far North Queensland.


**Existing network capability**

While there is thermal capacity for additional generation within this zone, without the coastal 275 kV circuit upgrade, future VRE generators (post Kaban Wind Farm) need additional investment. The upgrade also improves reliability to the Cairns area and provides greater resilience to Far North Queensland.

**Augmentation sequences**

| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | Progressive Change | Step Change | Slow Change | Hydrogen Superpower |
|---|---|---|---|---|---|---|---|
| • Conversion of one side of the coastal 132kV double-circuit transmission line to permanently operate at 275kV, as the third transmission line between Ross and Woree substations.<br>• Associated line reactor at the Woree Substation end.<br>• Establishment of a 275kV bus at Woree Substation.<br>• Construction of a 275kV bay at Ross Substation.<br>• Installation of a 275/132kV transformer at Tully Substation | Anticipated | Allow for up to 500 MW of new generation. | Anticipated project. | November 2023 | | | |

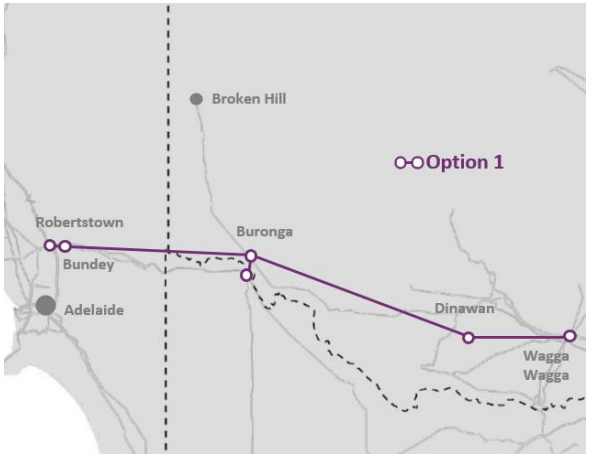
† See https://www.powerlink.com.au/sites/default/files/2021-09/Powerlink%20Queensland%20-%20Developing%20the%20Northern%20QREZ%20-%20Final%20Report.pdf.

## A5.3.6 Project EnergyConnect

**Summary**

Project EnergyConnect is a new 330 kV interconnector between New South Wales and South Australia. The interconnector runs from Robertstown in South Australia to Wagga Wagga in New South Wales, via the most north section of the transmission network in Victoria. It traverses between east and west, linking the REZ of Riverland, Murray River, and South West New South Wales, providing additional hosting capacity in these REZ.

ElectraNet and Transgrid completed the RIT-T and gained regulatory approval from the AER in May 2021*. This project does not meet all five criteria in the CBA Guidelines to assess commitment status of projects, hence it is classified as an anticipated project. Project EnergyConnect is expected to be completed by late 2024†. To allow time for inter-network testing, AEMO will model this augmentation at full capacity from July 2025.




**Existing network capability**

Presently no inter-connection between South Australia and New South Wales.

**Augmentation sequences**

| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | *Progressive Change* | *Step Change* | *Slow Change* | *Hydrogen Superpower* |
|---|---|---|---|---|---|---|---|
| Stage 1:<br>• A new Robertstown to Bundey 275 kV double-circuit line strung one circuit initially.<br>• A new Bundey to Buronga 330 kV double-circuit line strung one circuit initially.<br>• A new Buronga to Red Cliffs 220 kV double-circuit line strung one circuit only.<br>• A new 330/275 kV substation and a 330/275 kV transformer at Bundey.<br>• A new 330/220 kV substation, a 330/220 kV transformer and a 330 kV phase shifting transformer at Buronga.<br>• Static and dynamic reactive plant at Bundey and Buronga. | Anticipated | 800 MW<br>In both directions of NSW-SA<br>REZ network limit increase: 800 MW in S2, 600 MW in N5 | Anticipated project | June 2025 | | | |

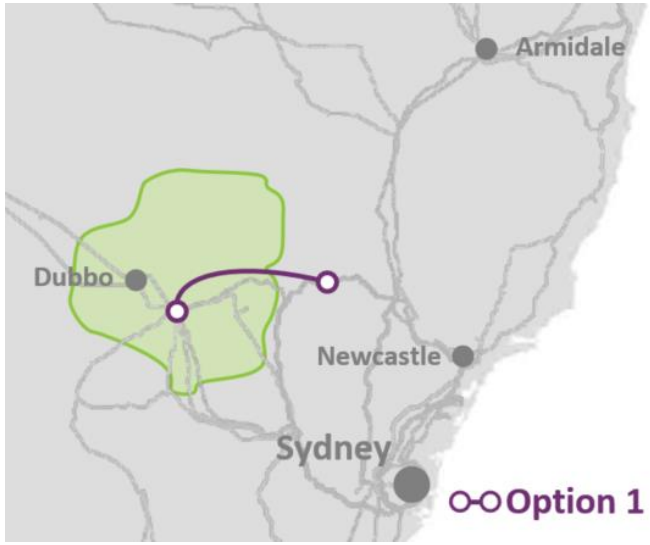
| | | | | |
|---|---|---|---|---|
| Stage 2:<br>• Second 275 kV circuit strung on the Robertstown–Bundey 275 kV double-circuit line.<br>• Second 330 kV circuit strung on the Bundey–Buronga 330 kV double-circuit line.<br>• A new 330 kV double-circuit line from Buronga to Dinawan.<br>• A new 500 kV double-circuit line from Dinawan to Wagga Wagga operating initially at 330 kV‡.<br>• Two additional new 330/275 kV transformers at Bundey.<br>• A new 330 kV switching station at Dinawan.<br>• Additional new 330 kV phase shifting transformers at Buronga.<br>• Additional new 330/220 kV transformer at Buronga.<br>• Turning the existing 275 kV line between Para and Robertstown into Tungkillo.<br>• Static and dynamic reactive plant at Bundey, Robertstown, Buronga and Dinawan.<br>• A special protection scheme to detect and manage the loss of either of the AC interconnectors connecting to South Australia. | | | | |

* AER. *TransGrid and ElectraNet – Project EnergyConnect contingent project*, at https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/contingent-projects/transgrid-and-electranet-%E2%80%93-project-energyconnect-contingent-project.
† TransGrid. https://www.transgrid.com.au/media/j2llfv1u/transmission-annual-planning-report-2021.pdf.
‡ See https://www.minister.industry.gov.au/ministers/taylor/media-releases/government-supporting-delivery-critical-transmission-infrastructure-southwest-nsw.

## A5.3.7 Central-West Orana REZ Transmission Link

**Summary**

Central-West Orana REZ has been identified by the New South Wales Government as the state's first pilot REZ. The NSW *Electricity Infrastructure Investment Act 2020* legislates the REZ be declared with an intended 3,000 MW of additional transmission network capacity within the Central-West Orana region of the state. REZ design and community engagement is currently progressing. In early November 2021, Central-West Orana was formally declared a Renewable Energy Zone as the first step to formalising the REZ under the *Electricity Infrastructure Investment Act 2020*.




**Existing network capability**

The project to establish the Central-West Orana REZ is considered anticipated, and as such the existing network capability is approximately 3,900 MW.

Due to the nature of the project, which is currently going through consultation on corridor selection, specific information on the project is not able to be provided.

**Augmentation sequences**

| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | *Progressive Change* | *Step Change* | *Slow Change* | *Hydrogen Superpower* |
|---|---|---|---|---|---|---|---|
| New transmission lines connecting to a 500 kV and 330 kV loop in the vicinity of the Central-West Orana REZ indicative location. | Anticipated | 3,000 | Anticipated project. | 2024 | | | |

## A5.3.8 Western Victoria Transmission Network Project

**Summary**

The Western Victoria Transmission Network Project is a combination of 500 kV and 220 kV transmission augmentations to alleviate constraints identified on the 220 kV network in Western Victoria. These augmentations will address network constraints due to the existing and committed large-scale renewable generation within the area.

A RIT-T was completed in July 2019†. Minor transmission line augmentations, including wind monitoring and upgrading station limiting transmission plant, on the Red Cliffs to Wemen to Kerang to Bendigo, and Moorabool to Terang to Ballarat, 220 kV transmission lines were completed in 2021 through AusNet Services' Network Capability Incentive Project Action Plan.

The remainder of the augmentation includes construction of new 500 kV and 220 kV transmission lines and a new 500/220 kV terminal station near Ballarat. This project is classified as an anticipated project, and is expected to be completed in late 2025.


**Existing network capability**

The existing network capability does not allow full dispatch of existing and committed renewable generation in Western Victoria and Murray REZ at times of high generation output.

**Augmentation sequences**

| Description | Status | Additional network capability (MW) | Expected cost ($ million) | *Progressive Change* | *Step Change* | *Slow Change* | *Hydrogen Superpower* |
|---|---|---|---|---|---|---|---|
| Option 1:<br>• A new 220 kV double-circuit transmission lines from Bulgana Terminal Station to Waubra Terminal Station to the new terminal station north of Ballarat.<br>• A new 500 kV double-circuit transmission lines from Sydenham to a new terminal station north of Ballarat.<br>• A new 500/220 kV terminal station north of Ballarat with two new 1,000 MVA 500/220 kV transformers. | Anticipated | This option accommodates existing plus committed generation in V3. | Anticipated project. | November 2025 | | | |

† AEMO. Western Victoria Renewable Integration, at https://www.aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/victorian_transmission/2019/pacr/western-victoria-rit-t-pacr.pdf.

## A5.4 Actionable ISP Projects

Five actionable projects are identified in the Draft ISP. For each actionable project, this section specifies ISP candidate options– which are credible options that must be considered as part of the RIT-T.

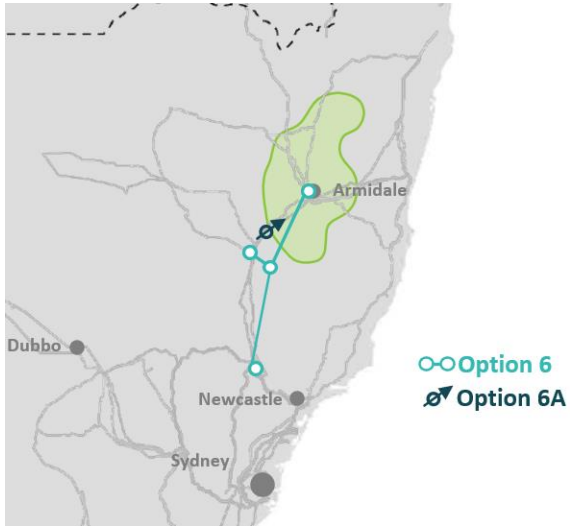
### A5.4.1 New England REZ Transmission Link

**Summary**

The NSW *Electricity Infrastructure Investment Act 2020* legislates the New England REZ be declared with an intended 8,000 MW of additional transmission network capacity. New England is located to the east of and along the existing QNI. Network expansion from Central New South Wales (CNSW) to connect to the New England REZ would help increase transfer capacity for QNI upgrade options.

New England REZ has moderate to good wind and solar resources in close proximity to the 330 kV network. Interest in the area includes large-scale solar and wind generation as well as pumped hydro generation. As generation further increases in North West New South Wales and New England REZs, increased connection capacity between the two REZs may be required. The sharing of resources across the network augmentation will allow for better transmission utilisation and reduction in transmission build.

500 kV transmission options were identified to access renewable generation in New England REZ to CNSW.




**Existing network capability**

The existing network capacity, following completion of the committed QNI Minor upgrade, is limited by transient and voltage stability on the circuits between Bulli Creek, Sapphire and Dumaresq. Thermal limits on the 330 kV circuits between Armidale, Tamworth, Muswellbrook and Liddell can also restrict flows on this network.

CNSW to NNSW maximum transfer capability is 910 MW at peak demand, summer typical and winter reference periods. The maximum transfer capability is limited by voltage stability for loss of Kogan Creek generator.

NNSW to CNSW maximum transfer capability is 930 MW at peak demand and summer typical periods and 1,025 at winter reference period. The maximum transfer capability is limited by thermal capacity of Armidale–Tamworth 330 kV lines following a credible contingency[†].

| ISP candidate options | | | | |
|---|---|---|---|---|
| **Description** | **Status** | **Additional network capacity (MW)** | **Expected cost ($ million)** | **Timing** |
| CNSW – NNSW Option 6 & 6A:<br>• A new 500 kV double-circuit line from locality of Armidale South to Bayswater via east of Tamworth.<br>• A new 500/330 kV substation with two 1,500 MVA transformers in locality of Armidale South.<br>• A new 500/330 kV substation in locality of east of Tamworth.<br>• A new 330 kV circuit from the locality of east of Tamworth to Tamworth.<br>• A new 330 kV double-circuit line from a new substation in locality of Armidale South to Armidale.<br>• Reconnect both Tamworth–Armidale 330 kV lines from Armidale to a new substation in locality of Armidale South.<br>• 500 kV line shunt reactors at both ends of locality of Armidale South–locality of east of Tamworth and locality of east of Tamworth–Bayswater.<br>• Power flow controllers on each of the Armidale-Tamworth 330 kV circuits.<br>• A +/- 400 MVAr SVC at locality of east of Tamworth. | Actionable | 3,070 MW in both flow directions.<br>Increase of N2 REZ network limit to 3,070 MW | 1,905<br>(±50%) | July 2027 |

† Transgrid published a Project Specification Consultation Report for managing risk on Tamworth – Armidale 330 kV line (Line 86) on 1 December 2021. Options include transfer capability improvement between Tamworth and Armidale. AEMO will consult with Transgrid on these options and their impact on transfer capability. Available at https://www.transgrid.com.au/projects-innovation/managing-risk-on-line-86-tamworth-armidale.

## A5.4.2 Sydney Ring (Reinforcing Sydney, Newcastle, and Wollongong Supply)

**Summary**

The transmission network in the Sydney, Newcastle and Wollongong (SNW) area was originally designed to connect large coal-fired generators in the Hunter Valley to supply the SNW load centres. When coal-fired generators around Newcastle retire, the network has insufficient capability to supply SNW load centres from generators located outside of the SNW area. Additional transmission network augmentation to connect with Central New South Wales (CNSW), local generation within SNW and/or energy storage within SNW is needed to supply the load centres within SNW area.

In the 2020 ISP, AEMO recommended that Transgrid complete preparatory activities for reinforcement of SNW supply. Transgrid proposed three options to increase the maximum network transfer capability from CNSW to SNW. Option 1 is a 500 kV double-circuit line between Bayswater and Eraring (Sydney Ring Northern 500 kV loop), Option 2 is a 500 kV double-circuit line between Bannaby and new substation near South Creek (Sydney Ring Southern 500 kV loop), and Option 3 is a combination of both Sydney Ring Northern and Southern 500 kV loops.

Draft ISP modelling identified Option 1 (Sydney Ring Northern loop); however a RIT-T could investigate both options for the most economical and environmentally acceptable outcome.


**Existing network capability**

The existing transfer capability varies depending on load and generation distribution within the Sydney, Newcastle and Wollongong areas.

The maximum transfer capability from CNSW to SNW is 7,525 MW at peak demand and summer typical and 7,625 at winter reference periods. With no Eraring and Vales Point generation, the maximum transfer capability reduces to 6,125 MW at peak demand and summer typical and 6,225 MW at winter reference periods. The maximum transfer capability is limited by a number of 330 kV lines between Bannaby and Liddell following a credible contingency.

**ISP candidate options**

| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | Timing |
|---|---|---|---|---|
| Option 1: Sydney Ring Northern 500 kV loop:<br>• A new 500 kV double-circuit line between Eraring substation and Bayswater substation.<br>• A new 500 kV substation near Eraring (Additional scope added by AEMO).<br>• Two 500/330 kV 1,500 MVA transformers at Eraring substation. | Actionable | 5,000<br>(This capacity increase for accommodation of additional new generation from North of Bayswater and 2/3 generation from Central West NSW) | 880<br>(±50%) | July 2027 |

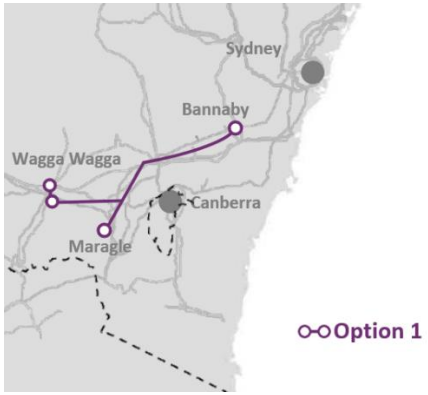
| | | | | |
|---|---|---|---|---|
| Option 2: Sydney Ring Southern 500 kV loop:<br>• A new 500 kV double-circuit line from the Bannaby substation to a new overhead/underground transition site.<br>• 8 km of tunnel installed underground 500 kV cables from the transition site to new substation in the locality of South Creek *(additional scope added by AEMO)*.<br>• Establish 500/330 kV substation in the locality of South Creek.<br>• Cut-in both Eraring – Kemps Creek 500 kV circuits at the new substation in the locality of South Creek.<br>• Two new 500/330 kV 1,500 MVA transformers at the new substation in the locality of South Creek.<br>• Replace a section of existing Bannaby-Sydney West 330 kV to double-circuit line between the locality of South Creek and Sydney West.<br>• Uprate the existing line between Bannaby and the locality of South Creek from 85°C to 100°C operating temperature.<br>• Cut-in Bayswater – Sydney West 330 kV line at South Creek.<br>• Cut-in Regentville – Sydney West 330 kV line at South Creek. | Alternative option | 4,500<br>(This capacity increase for accommodation of additional new generation from South of Bannaby and 1/3 generation from Central-West NSW) | 2,256<br>(±50%) | Alternative option |

## A5.4.3 HumeLink

**Summary**

HumeLink is a proposed transmission network augmentation that reinforces the New South Wales southern shared network to increase transfer capacity to New South Wales load centres. Transgrid is currently undertaking a RIT-T for this network augmentation. The PACR, the third report of the RIT-T, was published in July 2021†.

HumeLink optimises benefits to consumers if staged, targeting delivery by 2026-27, to protect consumers against schedule slippage, further coal closures or delays in medium-duration storage development, while retaining the option to pause the project if circumstances change. It is the only identified actionable ISP transmission project that could be delivered in that time frame to help mitigate these risks.




**Existing network capability**

The maximum transfer capability from SNSW to CNSW is 2,700 MW at peak demand and summer typical and 2,950 MW at winter reference periods. The maximum transfer capability is limited by thermal capacity of Yass–Marulan or Crookwell–Bannaby 330 kV lines following a credible contingency.

The maximum transfer capability from CNSW to SNSW is 2,320 MW at peak demand and summer typical and 2,590 MW at winter reference periods. The maximum transfer capability is limited by thermal capacity of Yass–Canberra or Marulan–Yass or Gullen Range–Bannaby 330 kV lines following a credible contingency.

**ISP candidate option**

| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | Timing |
|---|---|---|---|---|
| • New Wagga Wagga 500/330 kV substation and 330kV double-circuit connection to the existing Wagga Wagga 330kV substation.<br>• Three new 500 kV transmission lines:<br>– Between Maragle and Bannaby 500 kV substations,<br>– Between Maragle and new Wagga Wagga 500 kV substations, and<br>– Between new Wagga Wagga and Bannaby 500 kV substations.<br>• Three 500/330 kV 1,500 MVA transformers at Maragle.<br>• Two 500/330 kV 1,500 MVA transformers at new Wagga Wagga.<br>• 500 kV Line shunt reactors at the ends of Maragle – Bannaby, Maragle – new Wagga Wagga and new Wagga Wagga – Bannaby 500 kV line. | Actionable with early works | 2,200 MW in both directions.<br><br>REZ network limit increase: 1,600 MW in N6 | 3,315 (including $330 million for early works‡) | Early works: 2024<br>Implementation: Target July 2026 |

† TransGrid. HumeLink PACR, at https://www.transgrid.com.au/media/rxancvmx/transgrid-humelink-pacr.pdf.

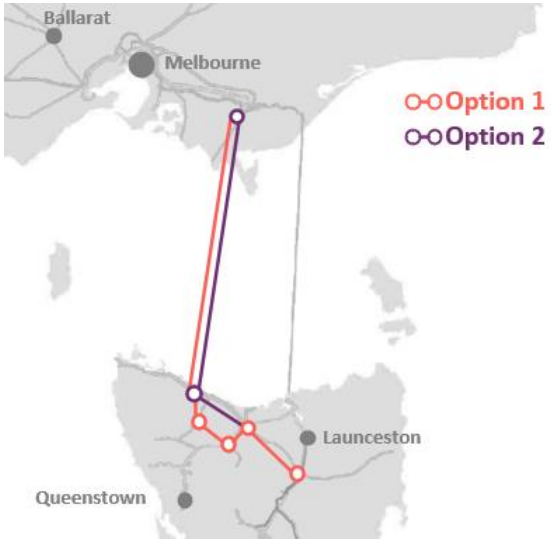
‡ The early works for HumeLink are assumed to cost $330m, of which $50m would need to be re-spent at a later date if the project was delayed for an extended period.

## A5.4.4 Marinus Link

**Summary**

Marinus Link is a proposed 1,500 MW capacity undersea and underground electricity connection between Tasmania and Victoria in addition to the existing Basslink. It is proposed to be delivered in two 750 MW high voltage direct current (HVDC) developments between Burnie area in Tasmania and Hazelwood area in Victoria. This project also includes alternating current (AC) transmission network developments on the North West Tasmanian electricity network.

TasNetworks has recently completed a RIT-T for this network augmentation. The project assessment conclusions report (PACR), the third report of the RIT-T, was published in June 2021*.




**Existing network capability**

The transfer capacity between Tasmania and Victoria is limited by thermal capability of Basslink (HVDC system between Tasmania and Victoria).

Transfer capacity between Tasmania and Victoria is limited to 478 MW in both directions at times of peak demand, summer typical and winter reference periods.

Additional network upgrades may also be required for the Central Highlands REZ for new generation connecting in the south of the REZ in order to access the network upgrades associated with Marinus Link.

**ISP candidate options**

| Description | Status | Additional network capacity (MW) | Expected cost** | Timing |
|---|---|---|---|---|
| Option 1 (Marinus Link – Cable 1)†<br>• A 750 MW monopole high voltage direct current (HVDC) link between Heybridge (near Burnie) in Tasmania and Hazelwood area in Victoria.<br>• Construction of a new 220 kV switching station at Heybridge adjacent to the converter station.<br>• Establishment of a new 220 kV switching station at Staverton.<br>• Construction of a new double-circuit 220 kV alternative current (ac) transmission line from Staverton to Heybridge via Hampshire and Burnie. | Actionable | Marinus Link:<br>750 in both directions.<br>Basslink and Marinus Link<br>VIC to TAS 978<br>REZ T2 or T3: 800 MW. Modelled as 400 MW in each. | $2.3 billion<br>(±15%) | July 2027# |

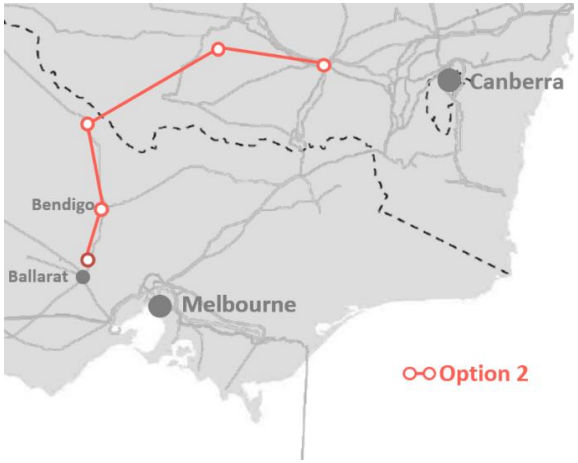
| | | | | |
|---|---|---|---|---|
| • Construction of a new double-circuit 220 kV AC transmission line from Palmerston to Sheffield.<br>• A new 500 kV ac connection between HVDC converter station and Victorian transmission network in Hazelwood area. | | | | |
| Option 2 (Marinus Link – Cable 2)<br>• A second 750 MW monopole HVDC link between Heybridge (near Burnie) in Tasmania and Hazelwood area in Victoria.<br>• Construction of a new double-circuit 220 kV transmission line from Heybridge to Sheffield and the decommissioning of the existing 220 kV single-circuit transmission line in this corridor.<br>Pre-requisite: Option 1 (Marinus Link – Cable 1) | Actionable | Marinus Link:<br>750 in both directions.<br>Basslink and Marinus Link Cables 1 and 2<br>VIC to TAS 1,728<br>REZ T2 or T3: 800 MW. Modelled as 400 MW in each. | $1.2 billion<br>(±15%) | July 2029 |

* TasNetworks. Project Marinus PACR, at https://www.marinuslink.com.au/wp-content/uploads/2021/06/Project-Marinus-RIT-T-PACR.pdf.
** Cost estimates were sourced from the Project Marinus PACR. In Draft ISP modelling, AEMO assumed early works cost $139 million (after discounting $50 million in grant funding), cable 1 costs $2,081 million, and cable 2 costs $1,210 million. For the final 2022 ISP, early works will be combined with cable 1 costs, and the figures will be escalated from 2020 to 2021 dollars. This results in cable 1 costing approximately $2.3 billion and cable 2 costing $1.2 billion.
† Connection between Staverton and Sheffield will make use of the existing 220 kV transmission lines.
# TasNetworks had now advised that the earliest full commercial use date for the first cable is July 2029. This revised date will be reflected in the final 2022 ISP, but preliminary modelling indicates that it does not materially change the outcomes of the ODP.

## A5.4.5 VNI West

**Summary**

A RIT-T is in progress for a large new interconnector between Victoria and New South Wales (VNI West) by AEMO and Transgrid. The 2020 ISP recommended two candidate options for VNI West – one via Kerang and one via Shepparton. Since the publication of 2021 IASR in July 2021, the scope of Project EnergyConnect (see Section A5.3.6) has changed to build the double-circuit lines from Dinawan to Wagga Wagga at 500 kV and operate them initially at 330 kV. This has reduced the cost estimate for the VNI West option via Kerang. The Kerang option also provides increased connection to the South West NSW, Murray River and Western Vic REZs. The Draft ISP therefore selects VNI West via Kerang as the only ISP candidate option for VNI West in the draft ODP.




**Existing network capability**

Transfer capability of future options will be modelled with committed projects of VNI minor upgrade and Victoria System Integrity Protection Scheme (SIPS) with battery storage for increased transfer capability from SNSW to Victoria.

Victoria to SNSW maximum transfer capability is 870 MW at peak demand and 1,000 MW at summer typical and winter reference periods. The maximum transfer capability is limited by voltage stability or transient stability limit.

The maximum transfer capability from SNSW to Victoria is 400 MW at peak demand, summer typical and winter reference periods. This is limited by a voltage stability limit. When available, Victoria's SIPS allows the 330 kV lines between South Morang and Murray to operate at a higher thermal capacity for a short period following a critical contingency.

**ISP candidate options**

| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | Timing |
|---|---|---|---|---|
| VNI West (via Kerang)<br>• A new 500 kV double-circuit line from north of Ballarat to near Bendigo to near Kerang to locality of Dinawan.<br>• Upgrade Dinawan to near Wagga Wagga 500 kV double-circuit line from 330 kV to 500 kV operation.<br>• Establish Dinawan 500 kV switchyard with two 500/330 kV 1,500 MVA transformers.<br>• New substations near Bendigo and near Kerang.<br>• Two 500/220 kV 1,000 MVA transformers at each of the new substations near Bendigo and near Kerang.<br>• 220 kV connections from the existing terminal station at Bendigo to new terminal station near Bendigo. | Actionable with early works | North: 1,930 MW<br>South: 1,800 MW<br>REZ network limit increase: 1,600 MW in V2, 550 MW in V3 | 2,942<br>(Including $491 million for early works[†]) | Early works: 2026<br>Implementation: Target July 2031 |

| | | | | |
|---|---|---|---|---|
| • 220 kV connections from the existing terminal station at Kerang to new terminal station near Kerang.<br>• Power flow controllers to prevent overloading on 330 kV lines between Upper/Lower Tumut and South Morang and, 220 kV lines between Dederang and Thomastown.<br>• 500 kV line shunt reactors at both ends of North of Ballarat - near Bendigo, near Bendigo - near Kerang, near Kerang - Dinawan and Dinawan - near Wagga Wagga 500 kV circuits.<br>• Up to +/- 400 MVAr dynamic reactive compensation at the new 220 kV terminal station near Kerang. | | | | |

† The early works for VNI West are assumed to cost $491m, of which $25m would need to be re-spent at a later date if the project was delayed for an extended period.

## A5.5 Future ISP projects

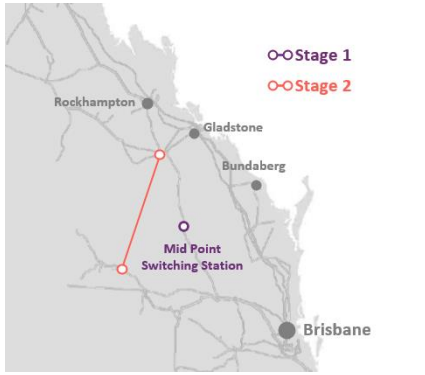
Future ISP projects deliver net market benefits to consumers but are not needed until later in the horizon. The optimal timing for each scenario's least-cost optimal is shown.

### A5.5.1 Central to Southern Queensland

**Summary**

The maximum transfer capability from Central and Northern Queensland (CNQ) to Southern Queensland (SQ) is currently limited to approximately 2,100 MW. As new generation connects in CNQ, congestion along this corridor will increase and generation will be curtailed.

In the 2020 ISP, AEMO recommended Powerlink complete preparatory activities to increase transfer capability from CNQ to SQ. In the Draft ISP, two options were selected. One option makes use of the existing transmission line with a mid-point switching station and the other option includes a new double-circuit transmission line.




**Existing network capability**

CNQ to SQ maximum transfer capability is approximately 2,100 MW. This capability is applicable in peak demand, summer typical, and winter reference periods. The maximum power transfer from CNQ to SQ grid section is limited by transient or voltage stability following a Calvale to Halys 275 kV circuit contingency.

In the reverse direction, SQ to CNQ maximum transfer capability is 700 MW at peak demand and summer typical levels and 1,000 MW at winter reference periods. The maximum transfer capability from SQ to CNQ is limited by thermal capacity of the Blackwall – South Pine 275 kV line following a credible contingency.

**Augmentation sequences**

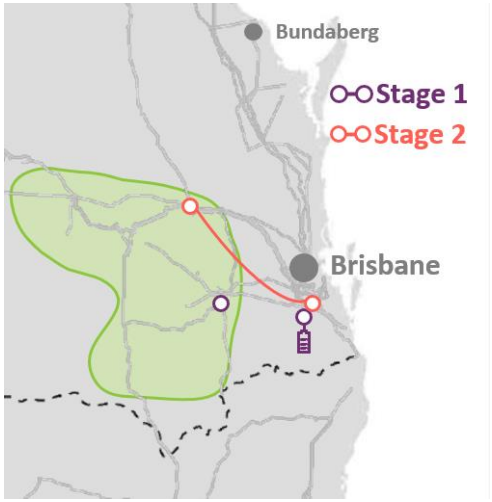
| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | *Progressive Change* | *Step Change* | *Slow Change* | *Hydrogen Superpower* |
|---|---|---|---|---|---|---|---|
| Stage 1:<br>• Mid-point switching substation on the Calvale –Halys 275 kV double-circuit line. | Future | North: 300 MW<br>South: 300 MW<br>Increase in REZ Network Limit NQ3: 300 MW | 55 | 2030-31 | 2028-29 | Not required | 2028-29 |
| Stage 2†:<br>• A new 275 kV double-circuit line between Calvale and Wandoan South.<br>• 275 kV line shunt reactors at both ends of Calvale – Wandoan South 275 circuits. | Future | North: 900 MW<br>South: 900 MW<br>Increase in REZ Network Limit NQ3‡: 900 MW | 476 | 2038-39 | 2038-39 | 2040-41 | 2030-31 |

† Stage 2 costs were provided by Powerlink. Class and the accuracy band as per Powerlink advice.
‡ NQ3 network limit modelled using the sub-regional cut-set, and not a separate limit.

## A5.5.2 Darling Downs REZ Expansion

**Summary**

The Darling Downs REZ extends from the border of New South Wales near Dumaresq, up to Columboola within the Surat region of Queensland, and has good solar and wind resources. A number of large solar and wind projects are already connected within the zone.




**Existing network capability**

The Darling Downs REZ has high network capacity and is near QNI and Brisbane. Furthermore, the ultimate retirement of generation within this REZ will allow for increased VRE connections.

Under high demand conditions, this corridor can only facilitate 1,300 MW into the greater SEQ area from generation connected around the Bulli Creek area. Generation connected around the Halys area will be required to allow the full 3,000 MW REZ capacity to be able to be utilised. The Middle Ridge site is very constrained – further investigation is required to determine the feasibility of any expansion of this substation.

The scope and costs of future larger network upgrades are indicative and require further review in consultation with the TNSP. The timing of these upgrades will also be influenced by generation retirements and any QNI upgrades.

Due to the large amount of generation flagged for connection in this REZ, co-ordination of new generation and network requirements is expected to be required.

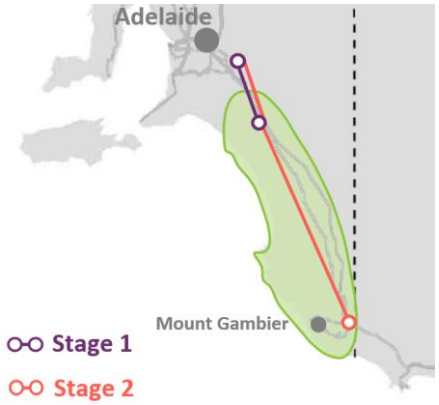
**Augmentation sequences**

| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | *Progressive Change* | *Step Change* | *Slow Change* | *Hydrogen Superpower* |
|---|---|---|---|---|---|---|---|
| Stage 1:<br>• Replace existing 1,300 MVA 330/275 kV transformer at Middle Ridge with 1,500 MVA 330/275 kV transformer.<br>• Implement a post-contingent bus-splitting scheme at Middle Ridge and a Special Protection scheme involving 300 MW SEQ Battery Energy Storage System (BESS) and generation runback within Q8 REZ. | Future | 800 | 43 + BESS contract costs | 2035-36 | 2028-29 | 2049-50 | 2025-26 |
| Stage 2 (conceptual):<br>• 500 kV double-circuit network expansion from vicinity of Halys / Western Downs. | Future | 2,500 | 1,160 | 2046-47 and 2048-49 | 2039-40 and 2048-49 | - | 2033-34 and 2036-37<br>An additional 3,300 MW REZ network capacity required by 2049-50 |

## A5.5.3 South East South Australia REZ expansion

**Summary**

The South East South Australia REZ lies on the major 275 kV route of the South Australia – Victoria Heywood interconnector. The REZ has moderate to good quality wind resources as is evidenced by the high proportion of wind generation (over 300 MW) in or near the South East border with Victoria.




**Existing network capability**

There is currently no additional network hosting capacity available in this REZ without further augmentation. Network augmentations would be smaller if generation is located relatively close to Adelaide, and larger if located further south towards Mount Gambier.

If generation locates nearer to Adelaide, then results show network augmentation may be justified by 2029-30 in the *Step Change* scenario. Additional augmentation may be required by 2035-36 under the *Step Change* scenario, however it is noted further work is required to determine suitable larger augmentation options and the associated costs. This will involve further consultation and co-ordination of potential new generation and network builds with ElectraNet.

High network augmentation costs or inability to connect generation in this part of the network could result in earlier Mid North SA REZ expansion requirements.

**Augmentation sequences**

| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | *Progressive Change* | *Step Change* | *Slow Change* | *Hydrogen Superpower* |
|---|---|---|---|---|---|---|---|
| Stage 1:<br>• String vacant circuit on the 275 kV Tungkillo – Tailem Bend line.<br>• 100 MVAr SVC at Tailem Bend.<br>• Assumes following NCIPAP project in place:<br>– Turn in 275 kV circuit Tailem Bend to Cherry Gardens at Tungkillo†. | Future | 600 | 57 | 2035-36 | 2029-30 | 2046-47 | 2025-26 |
| Stage 2 (conceptual):<br>• Additional 275 kV lines between South East-Tailem Bend-Tungkillo, dependant on new generation location. | Future | 950 | 949 | 2040-41 and 2045-46 | 2035-36 and 2045-46 | - | 2028-29 and 2033-34<br>An additional 12,500 MW REZ network capacity required by 2049-50 |

† This upgrade component has been flagged as a Network Capability Incentive Parameter Action Plan (NCIPAP) upgrade by ElectraNet and is treated as a committed project. Hence, the cost for this component is not included in the expected cost. This project is complimentary to Option 1 and assists in realising the network capacity.

## A5.5.4 Gladstone Grid Reinforcement

**Summary**

Following the retirement or reduced generation from Gladstone Power Station and increased generation in North Queensland, transmission network which supply to the Gladstone area will be constrained. As a result, forecast demand at Boyne Island, Calliope River, Larcom Creek and Raglan substations cannot be supplied.

In the 2020 ISP, AEMO recommended Powerlink complete preparatory activities for reinforcement of Central and North Queensland (CNQ) and Gladstone Grid (GG) section. New 275 kV transmission lines are proposed to increase the network transfer capability between CNQ and GG.


**Existing network capability**

The maximum power transfer capability is influenced by the amount of generation dispatch within northern and central Queensland, particularly at Gladstone. This limit is influenced by the thermal capacity of the Calvale–Wurdong, Bouldercombe–Raglan, Larcom Creek–Calliope River or Calliope River–Wurdong 275 kV circuits.

- With typical generation output from Stanwell and Callide, CNQ to GG maximum transfer capability is 700 MW at peak demand and summer typical levels, and 1,050 MW at winter reference condition.
- In the reverse direction, GG to CNQ maximum transfer capability is 750 MW at peak demand and summer typical levels and approximately 1,100 MW at winter reference periods.

**Augmentation sequences**

| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | Progressive Change | Step Change | Slow Change | Hydrogen Superpower |
|---|---|---|---|---|---|---|---|
| Option 1:<br>• New 275 kV double-circuit line between Calvale and Calliope River.<br>• Rebuild Calliope River to Larcom Creek 275 kV as a double-circuit line.<br>• Rebuild Larcom Creek to Bouldercombe 275 kV as a double-circuit line with one line tapped at Raglan.<br>• A new (third) 275/132 kV transformer at Calliope River. | Future | CNQ to GG: 550 MW<br>GG to CNQ: 500 MW | 408 | 2035-36 | 2030-31 | Not required | 2028-29 |

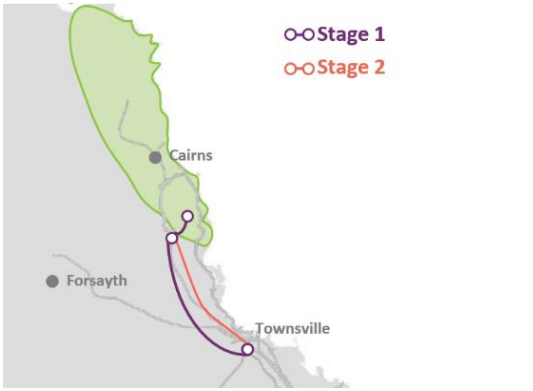
## A5.5.5 Far North Queensland REZ Expansion

**Summary**

The Far North Queensland (FNQ) REZ is at the most northerly section of Powerlink's network. It has excellent wind and moderate solar resources and has existing wind, solar and hydroelectric power stations.

Options proposed to expand network capacity in this REZ progressively increase network capacity and allow for upgrades based on where generation develops. Due to the large amount of generation flagged for connection in this REZ, and outcomes highlighting potential need for network upgrades prior to 2034-35, co-ordination of new generation and network expansion may be required.

For this remote part of the network, reducing MLFs may act as a disincentive for generation to connect, therefore additional investigations will be completed in the final 2022 ISP to explore investment risks relating to MLFs.




**Existing network capability**

Maximum export capability from the FNQ REZ is limited by voltage stability for a contingency of a Ross to Chalumbin 275 kV circuit. The existing network will allow for a total of approximately 750 MW of VRE to be connected.

Output from this REZ can also be limited by network capacity further south which can result in the need for additional network augmentations. Output from this REZ is limited by downstream network capacity (refer to the 2021 Transmission Cost Report for more information†).

**Augmentation sequences**

| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | *Progressive Change* | *Step Change* | *Slow Change* | *Hydrogen Superpower* |
|---|---|---|---|---|---|---|---|
| Stage 1:<br>• Establish a new 275 kV substation north of Millstream.<br>• Build a 275 kV double-circuit line from Chalumbin to Millstream.<br>• Rebuild the double-circuit Chalumbin–Ross 275 kV line at a higher capacity (possibly timed with asset replacement).<br>• Build additional Chalumbin-Ross 275 kV double-circuit tower but string and energise as a single-circuit line. | Future | 945 | 1,264 | 2037-38 | 2031-32 | - | 2028-29 |
| Stage 2: (Pre-requisite: Stage 1)<br>• String and energise the other Chalumbin-Ross 275 kV additional circuit. | Future | 345 | 155 | - | 2039-40 | - | 2029-30<br>An additional 10,000 MW REZ network capacity required by 2049-50 |

† At https://aemo.com.au/-/media/files/major-publications/isp/2021/transmission-cost-report.pdf?la=en.

## A5.5.6 Facilitating power to Central Queensland

**Summary**

Upgrade options associated with this flow path may be built when generation in REZs Q1 to Q5 (Northern Queensland) exceeds 2,500 MW. These augmentations facilitate transmission of generation in northern Queensland to load centres in the south.


**Existing network capability**

The current network was designed to facilitate the transmission of power from Central Queensland to support the load in Northern Queensland. Thus, its capacity was designed around North Queensland load, rather than building for future generation projects. As such, the network has the ability to support up to 2,500 MW of generation across the five REZs in Northern Queensland depending also on the level of storage in these REZs.

**Augmentation sequences**

| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | *Progressive Change* | *Step Change* | *Slow Change* | *Hydrogen Superpower* |
|---|---|---|---|---|---|---|---|
| Stage 1:<br>• Construct additional 275 kV circuit from Bouldercombe to Stanwell.<br>• String and energise the second Broadsound-Stanwell 275 kV circuit (on existing DCST). | Future | 400 | 137 | 2036-37 | 2031-32 | - | 2027-28 |
| Stage 2 (conceptual):<br>• Additional 275 kV double-circuit lines between Central and North Queensland. | Future | 1,400 | 816 | 2044-45 | 2038-39 and 2045-46 | - | 2029-30, An additional 48,000 MW REZ network capacity required by 2049-50 |

## A5.5.7 QNI Connect

**Summary**

The Northern New South Wales (NNSW) and Southern Queensland (SQ) corridor represents a portion of the network which forms part of the QNI. Development options on this corridor include the northern sections of proposed QNI Augmentations.

A project to increase the transfer capacity of the existing QNI (referred as 'QNI Minor') has been committed.

In addition to QNI Minor, in the 2020 ISP, AEMO recommended Powerlink and Transgrid complete preparatory activities for QNI interconnector upgrades. Powerlink and Transgrid proposed two 330 kV options. One option (stage 1) is a single-circuit strung on a 330 kV double-circuit line and the other option (stage 2) is to string a second circuit to the same 330 kV double-circuit line.


**Existing network capability**

Transfer capability with future options will be modelled with QNI Minor upgrade in service.

- NNSW to SQ maximum transfer capability is 685 MW at peak demand and 745 MW at summer typical and winter reference periods. The maximum transfer capability is limited by voltage or transient stability for loss of the Kogan Creek generator.
- In the reverse direction, SQ to NNSW maximum transfer capability is 1,205 MW, 1,165 MW and 1,170 MW at peak, summer typical and winter reference periods respectively. The maximum transfer capability is limited by thermal capacity of 330 kV lines between Armidale and Bulli Creek following a credible contingency.

**Augmentation sequences**

| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | *Progressive Change* | *Step Change* | *Slow Change* | *Hydrogen Superpower* |
|---|---|---|---|---|---|---|---|
| Stage 1 (option 1)†:<br>• A new 330 kV double-circuit line (one circuit strung) from locality of Armidale South to Dumaresq to Bulli Creek to Braemar.<br>• A new 330/275 kV transformer at Braemar.<br>• Cut-in Armidale–Dumaresq 330 kV line (8C) at Sapphire.<br>• 330 kV Line shunt reactors at Bulli Creek for the Bulli Creek–Braemar and Dumaresq–Bulli Creek 330 kV circuits. | Future | North: 910 MW<br>South: 1,080 MW | 1,253<br>(Combined cost of NSW and QLD works) | 2036-37 | 2032-33 | 2035-36 | 2029-30 |

† Additional augmentation is required later in the horizon for some scenarios, see Table 1.

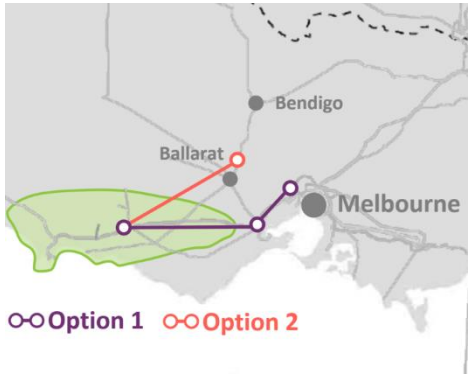
## A5.5.8 South West Victoria REZ Expansion

**Summary**

The South West Victoria REZ has moderate to good quality wind resource in close proximity to the 500 kV and 220 kV networks in the area.

The total committed and in-service wind generation in the area exceeds 2 GW.

Due to the large amount of generation flagged for connection in this REZ, and outcomes highlighting potential need for network upgrades prior to 2035, co-ordination of new generation and network expansion may be required.




**Existing network capability**

Due to the strong level of connection interest, there are emerging network capacity limits.

The current total network hosting capacity is approximately 2,500 MW for this REZ.

**Augmentation sequences**

| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | *Progressive Change* | *Step Change* | *Slow Change* | *Hydrogen Superpower* |
|---|---|---|---|---|---|---|---|
| Option 1:<br>• New 500 kV single-circuit line between Mortlake – Moorabool – Sydenham. | Future | 1,500 | 930 | - | 2033-34 | - | 2030-31 |
| Option 2:<br>• New 500 kV single-circuit line between Mortlake - north of Ballarat.<br>• Turn Tarrone – Haunted Gully line into Mortlake substation. | Future | 1,200 | 851 | 2043-44 | - | - | 2033-34<br>An additional 9,000 MW REZ network capacity required by 2049-50 |

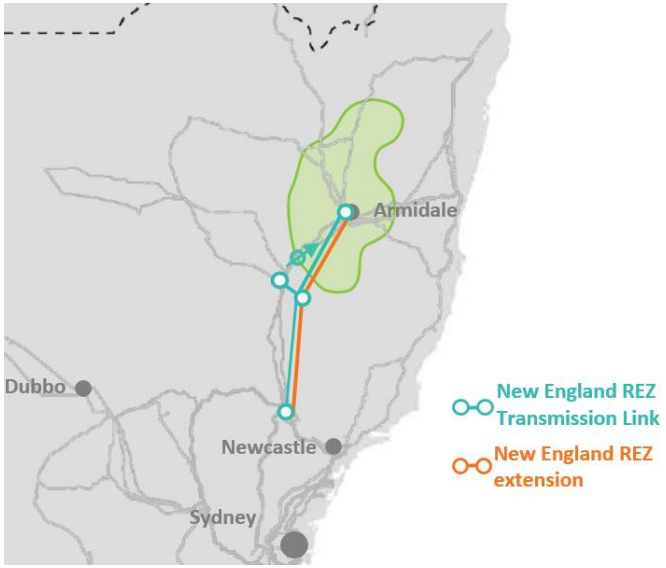
## A5.5.9 New England REZ Extension

**Summary**

The NSW *Electricity Infrastructure Investment Act 2020* legislates the REZ be declared with an intended 8,000 MW of additional transmission network capacity within the New England region of the state. New England REZ is located to the east of and along the existing QNI, and network expansion from CNSW to connect to the New England REZ would also assist to increase transfer capacity for QNI upgrade options.

New England REZ has moderate to good wind and solar resources in close proximity to the 330 kV network. Interest in the area includes large-scale solar and wind generation as well as pumped hydro generation. As generation further increases in North West New South Wales and New England REZs, increased connection capacity between the two REZs is likely to be required. The sharing of resources across the network augmentation will allow for better transmission utilisation and reduction in transmission build.

An actionable ISP project for New England REZ transmission link was identified in Section A1.4.1. With increased renewable generation in New England REZ, further additional new transmission options are required.




**Existing network capability**

The existing network capacity, following completion of the committed QNI Minor upgrade, is limited by transient and voltage stability on the circuits between Bulli Creek, Sapphire and Dumaresq. Thermal limits on the 330 kV circuits between Armidale, Tamworth, Muswellbrook and Liddell can also restrict flows on this network.

CNSW to NNSW maximum transfer capability is 910 MW at peak demand, summer typical and winter reference periods. The maximum transfer capability is limited by voltage stability for loss of the Kogan Creek generator.

NNSW to CNSW maximum transfer capability is 930 MW at peak demand and summer typical periods and 1,025 MW at winter reference period. The maximum transfer capability is limited by thermal capacity of Armidale–Tamworth 330 kV lines following a credible contingency.

With the actionable ISP project for New England REZ transmission link as identified in Section A1.4.1 (Options 6 and 6A) CNSW to NNSW transfer capacity increases by 3,070 MW in both directions.

**Augmentation sequences**

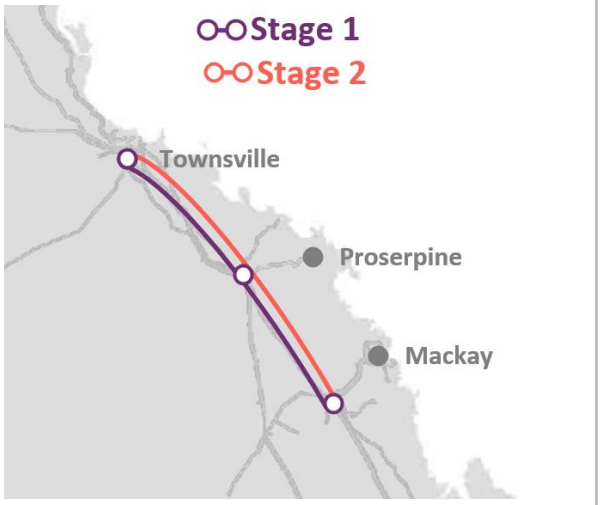
| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | *Progressive Change* | *Step Change* | *Slow Change* | *Hydrogen Superpower* |
|---|---|---|---|---|---|---|---|
| CNSW – NNSW Option 6B: Option 6 and 6A plus<br>• An additional new 500 kV double-circuit line from Armidale South to locality of east of Tamworth to Bayswater.<br>• An additional 500/330 1,500 MVA transformer at locality of Armidale South.<br>• An additional +/- 400 MVAr SVC at locality of east of Tamworth.<br>• 500 kV line shunt reactors at both ends of locality of Armidale South–locality of east of Tamworth and locality of east of Tamworth–Bayswater. | Future | 5,820 MW in both flow directions.<br>Increase of N2 REZ network limit to 5,820 MW | 3,142 | 2038-39 | 2035-36 | 2045-46 | 2031-32 |

## A5.5.10 Facilitating power out of North Queensland

**Summary**

Upgrade options associated with the northern to central Queensland flow path are optimally built when total generation in REZs Q1, Q2 and Q3 (North Queensland) exceed 2,200 MW. This augmentation option facilitates transmission from North Queensland to load centres in Central and Southern Queensland.

The timing for upgrades to this part of the network is expected to be linked to Q1 REZ expansion plans.




**Existing network capability**

The current network was designed to facilitate the transmission of power from Central Queensland to supply load in Northern Queensland. The network has the ability to support up to 2,200 MW of generation across the three REZs in North Queensland depending also on the level of storage in these REZs.

Scope and costs of future larger network upgrades are indicative and requires further review in consultation with the TNSP.

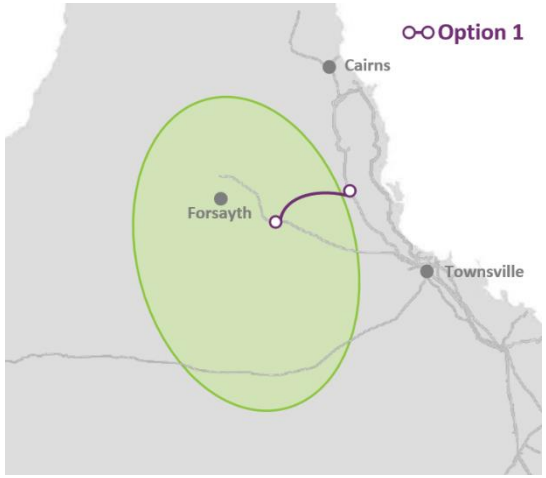
**Augmentation sequences**

| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | *Progressive Change* | *Step Change* | *Slow Change* | *Hydrogen Superpower* |
|---|---|---|---|---|---|---|---|
| Stage 1:<br>• Construct an additional circuit from Ross to Strathmore to Nebo. | Future | 740 | 801 | 2044-45 | 2038-39 | - | 2029-30 |
| Stage 2 (conceptual):<br>• Additional 275 kV double-circuit between Ross and Nebo regions. | Future | 1,400 | 862 | 2049-50 | 2039-40 | - | 2030-31<br>An additional 18,000 MW REZ network capacity required by 2049-50 |

## A5.5.11 North Queensland Clean Energy Hub

**Summary**

The North Queensland Clean Energy Hub REZ is at the north-western section of Powerlink's network, and has excellent wind and solar resources.




**Existing network capability**

Currently the REZ is supplied via a 132 kV line from Ross. Interest in this area includes the development of Kidston pumped storage project, for which Powerlink has recently received a 'Notice to Proceed' to develop a single-circuit 275 kV line†.

Output from this REZ can also be limited by network capacity further south, which can result in the need for additional network augmentations. With a single-circuit line, output may also be limited to ensure the largest generation contingency size does not impact on system security.

The scope and costs of future larger network upgrades are indicative and requires further review in consultation with the TNSP.

**Augmentation sequences**

| Description | Status | Additional network capacity (MW) | Expected cost ($ million) | *Progressive Change* | *Step Change* | *Slow Change* | *Hydrogen Superpower* |
|---|---|---|---|---|---|---|---|
| Option 1 (conceptual):<br>• Additional 275 kV double-circuit to Kidston Area. | Future | 1,000 | 529 | 2045-46 | 2038-39 | - | 2030-31<br>An additional 7,000 MW REZ network capacity required by 2049-50 |

† Powerlink, Genex-Kidston connection project, at https://www.powerlink.com.au/projects/genex-kidston-connection-project.

## A5.5.12 Other future ISP Projects

In addition to the projects identified in Section A5.5, Table 1 identifies indicative projects required towards the end of the modelling horizon which are expected to evolve from one ISP to the next. These projects are conceptual and vary significantly between scenarios in relation to size of network augmentation and the timing. AEMO welcomes feedback on these projects.

**Table 1 Indicative transmission and REZ augmentations required later in the horizon**

| REZ / flow path upgrade | Augmentation option (REZ network limit increase)* | *Progressive Change* | *Step Change* | *Slow Change* | *Hydrogen Superpower* |
|---|---|---|---|---|---|
| N8 – Cooma-Monaro | Option 2 – 330 kV circuit to Stockdill area (+500 MW). | 2035-36 | 2032-33 | 2047-48 | 2026-27 |
| N3 – Central West Orana | Option 1 – Additional 330 kV double-circuit to Mt Piper (+1,500 MW). | 2042-43 | 2040-41 | - | 2034-35 |
| V3 – Western Victoria | Option 2 – New double-circuit 220 kV line North of Ballarat to Bulgana (+800 MW). | 2046-47 | 2042-43 | - | 2033-34 |
| Q9 - Banana | Option 1 – 500 kV double-circuit lines to Gladstone area (+3,000 MW). | 2046-47 | 2042-43 | - | 2035-36 |
| MN1 – Mid North Group Constraint | Option 1 or 2 – Double-circuit lines between Robertstown and Davenport areas (+950 MW). | 2047-48 | 2042-43 | - | 2033-34 |
| S6 – Leigh Creek | Option 1 and 2 – Double-circuit 275 kV lines to Leigh Creek area (+950 MW). | 2047-48 | 2042-43 | - | 2028-29 |
| V3 – Western Victoria | Option 3 – New double-circuit line from Murra Warra-Horsham-Bulgana (+1,000 MW). | 2046-47 | 2045-46 | - | 2036-37 |
| Q7 – Wide Bay | Option 1 – Rebuild Woolooga – Palmwoods – South Pine 275 kV single-circuit line as a high capacity double-circuit line (+900 MW). | 2048-49 | 2045-46 | - | 2030-31 |
| | Option 2 – Rebuild Woolooga – South Pine 275 kV single-circuit line as a high capacity double-circuit line (+900 MW). | 2049-50 | 2047-48 | - | 2032-33 |
| V6 – Central North Victoria | Option 5 – New 220 kV circuit North of Bendigo to Shepparton area (+700 MW). | 2047-48 | 2047-48 | - | 2040-41 |
| N3 – Central-West Orana | Option 2 – Additional 500 kV single-circuit to Bayswater (+900 MW). | 2047-48 and 2049-50† | 2048-49 | - | 2037-38 |
| S2 – Riverland | Option 1 – Turn Bundey – Buronga 330 kV No. 1 and No. 2 lines into a new substation at Riverland (+700 MW). | - | 2048-49 | - | 2028-29 |

| REZ / flow path upgrade | Augmentation option (REZ network limit increase)* | *Progressive Change* | *Step Change* | *Slow Change* | *Hydrogen Superpower* |
|---|---|---|---|---|---|
| V2 - Murray River | Option 4 – New 220 kV circuits from Red Cliffs-Wemen-Kerang, post VNI West (+800 MW). | - | 2049-50 | - | 2038-39 |
| QNI Connect (Stage 2) | Stage 2 (option 2) – An additional new 330 kV circuit (second circuit strung) from locality of Armidale South to Dumaresq to Bulli Creek to Braemar. *Pre-requisite: QNI Connect (Stage 1).* | - | - | - | 2030-31 |
| Bayswater to Newcastle port augmentation | New three 500 kV lines from Bayswater to Newcastle port. | - | - | - | 2040-41 |
| N2 - New England REZ expansion | CNSW – NNSW Option 9 - 2,000 MW bi-pole HVDC transmission system between locality Bayswater and locality of Armidale South. | - | - | - | 2042-43 |
| Q2 – North Queensland Energy Hub | Option 1 – Additional 275 kV single-circuit to Kidston area (+500 MW). | - | - | 2044-45‡ | - |
| Victoria – New South Wales interconnector | VNI Option 6 – New 500 kV double-circuit line from north of Melbourne to Wagga Wagga via Central North Victoria. | - | - | - | 2045-46 |

* Option numbers refer to information in the 2021 Transmission Cost Report.
† Upgrades in addition to the project description are required in 2049-50 in the *Progressive Change* scenario only.
‡ Lower capacity upgrade required for the *Slow Change* scenario only.